United States Patent

Langford

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[54] HIGH VOLTAGE CONNECTOR FOR A NEUTRON GENERATOR COMPRISING A PLASTIC INSULATOR

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[52] **U.S. Cl.** .....**250/84.5,** 174/110 FC

[51] **Int. Cl.** **G21g 3/00**

[58] **Field of Search**.....250/84.5, 87, 90; 174/110 FC; 339/94 R, 177 R; 313/61 R, 63

[56] **References Cited**

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[57] **ABSTRACT**

High voltage connector apparatus for a radioactivity well logging tool. It has a solid conductor axially located within a moulded Teflon insulator. The insulator has a smooth transverse face acting as an end wall for a high pressure gas-containing section of the tool.

8 Claims, 2 Drawing Figures

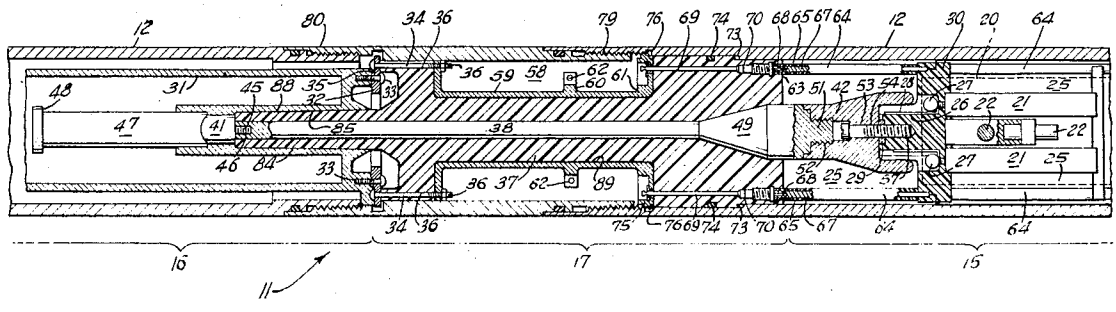


Fig. 1.

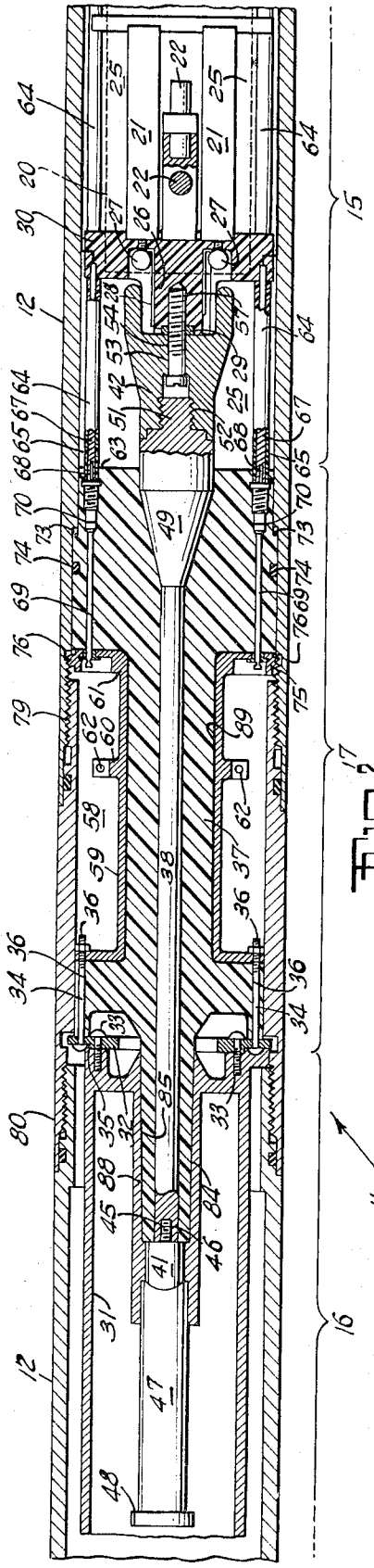
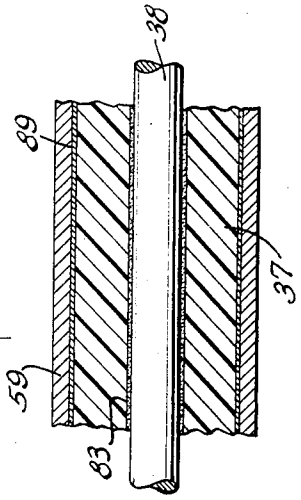


Fig. 2.



HIGH VOLTAGE CONNECTOR FOR A NEUTRON GENERATOR COMPRISING A PLASTIC INSULATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an electrical connector in general. More specifically, it concerns a special purpose electrical connector combined with particular insulator structure and arrangement. The combination is for use with a radioactivity type of borehole logging tool.

2. Description of the Prior Art

A problem area in connection with constructing borehole logging tools of the type used for radioactivity well logging has been the construction of a connector that will satisfactorily join the high voltage supply with the target of the neutron generator. Difficulties have been encountered with providing satisfactory electrical insulation, as well as with the physical qualifications required to electrically connect a high voltage source in a high pressure gas atmosphere to the target element of a neutron generator which is in an evacuated atmosphere. Electrical leakage and insulation breakdown are of concern, and in addition mechanical strength as related to the forces created by the pressurized gas atmosphere must be considered. In the past, use has been made of a unitary dividing structure that had high pressure gas on one side and a greatly reduced pressure atmosphere on the other. But, this entailed a special structure with tapered surfaces and it made use of a specially formed alumina type insulator.

This invention makes use of a plastic material as the insulator, and by reason of the structural arrangements as well as the type of plastic employed, a superior result has been obtained.

SUMMARY OF THE INVENTION

Briefly, this invention relates to a high voltage connector for a radioactivity type borehole logging tool neutron generator. The said tool has a cylindrical case for enclosing a high voltage generating section, a neutron generator section and a section for said connector. The connector of the invention comprises in combination an axially located solid stainless steel conductor having a polished surface and connecting said high voltage generating section with said neutron generator section. It also comprises a body of insulating material constructed of moulded polytetrafluoroethylene surrounding said conductor in close fitting relationship thereto over the entire length thereof in said connector section, and a smooth surface on said body of insulating material being substantially perpendicular to the axis of said tool. In the foregoing combination the said smooth surface forms an end wall for said high voltage generating section. The combination also comprises an annular chamber formed in said body of insulating material near the middle of said connector section for containing circuit elements to control the replenisher of said neutron generator, and an aluminum frame lining said annular chamber. The frame has means for mounting said circuit elements thereon. Finally, the combination also comprises electrically insulating grease located between said axial conductor and said body of insulating material for excluding air pockets. And, it comprises an electrically conductive coating on the outer surfaces of said body of insulating material for preventing build-up of excessive electrical fields across air gaps adjacent to said outer surfaces.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and benefits of the invention will be more fully set forth below in connection with the best mode contemplated by the inventor of carrying out the invention, and in connection with which there are illustrations provided in the drawings, wherein:

FIG. 1 is a partially schematic assembly illustrating a portion of a logging tool that incorporates the invention; and

FIG. 2 is an enlarged fragmentary showing of part of the middle section of the illustrated tool.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the construction of a radioactivity type of logging tool that is to be employed for well logging, there are difficulties that have been encountered relating to the problems stemming from the relatively small size of the tool structure and the high electrical potentials that are involved in operating a neutron generator. Such problems and difficulties have been overcome with highly satisfactory results by means of employing a new combination that is concerned with the structure of a high voltage connector. The connector is used to transmit the high electrical potential or voltage which is generated at the output of a voltage generating section of the tool, to the target element of a neutron generator in the tool.

The combination includes structure for accomplishing connection by an electrical conductor from a high voltage circuit to the target element of a self-contained neutron generator which is mounted in a borehole logging tool. The connector must have electrical insulation that can effectively isolate an electrical conductor from the casing of the tool while also withstanding the physical force created by temperature and high pressure gas that is provided in the high voltage generator section. In addition to accomplishing that function, there is provision made to have a chamber to accommodate circuit elements that are employed in controlling the replenisher of the neutron generator. As will be pointed out in more detail hereafter, such circuit elements need to be located close to the heating element of the replenisher but without interfering with a desirably short distance between the target of the neutron generator and the detector thereof.

Referring to FIG. 1, there is schematically illustrated a portion of a borehole radioactivity logging tool **11**. The tool has a case **12** which encloses all three sections of the tool, namely a high voltage generator section **15**, a neutron generator section **16** and a connector section **17**.

The high voltage generator section contains elements of a generator that will supply the necessary high voltage of electrical potential, e.g., a voltage of about 125 kv at rated load. Such generators are well-known and the indicated generator forms no part per se of this invention. However, there are schematically illustrated some of the elements relating to an output stage that includes one or more voltage multiplying sections. This is indicated in the drawing by a dashed line **20** that encloses one or more capacitors **21**, in addition to diodes **22** and the like.

All the elements that are contained in the high voltage generator section **15** are kept in a high pressure gas atmosphere. Thus, in the preferred modification there is a space **25** within the section **15** and extending from the left hand end thereof, as viewed in the drawing. This and the rest of section **15** contain sulfur hexafluoride gas under pressure of about 100 pounds per square inch. The pressure varies from somewhat less to considerably more than that, depending upon the temperature of the tool.

There are, of course, electrical circuit conductors for completing a circuit to carry the output voltage from section **15**. These might take various forms, and the details thereof form no part per se of the invention. However, there is a high voltage adapter plate **30** for supporting one end of the elements within the output stage (dashed line **20**). Plate **30** may be constructed of any feasible insulating material but it is preferably made of the plastic polytetrafluoroethylene commonly known by its trade name Teflon.

The plate **30** has a number of holes (not shown) located near the periphery that extend through the plate for permitting free passage of the high pressure gas within the section **15** of the tool. The plate is counter bored to receive ball shaped heads **27** of conductive material screws that screw into terminal studs (not shown) of the capacitors **21**. The counter bores form longitudinal grooves along the sides of the hub, and the high voltage circuit is carried from one of the heads **27** over a wire **28** to a conductive material washer or ring **29**. The

wire 28 may be connected at each end in any feasible manner, e.g., by having an eyelet under the head 27 and being soldered to the washer 29.

Located in the neutron generator section of the tool 11, there is a neutron generator 31. It might take various forms, and forms no part per se of the invention. The type generator indicated is one like that manufactured under the trade name Amperex. It is supported within the case 12 in coaxial relation therewith. Its support at one end is by means of a stainless steel support ring 32 that is attached on the end of the neutron generator 31 by means of a plurality of screws 33, as illustrated.

The plate or support ring 32 (along with its attached neutron generator 31) is mounted axially within the case 12 by means of having a plurality of screws 36 facing the other way from screws 33. These extend through a peripheral flange 35 on the ring 32. They also go through a corresponding number of peripherally located holes 34 near one end of a body member 37.

Body member 37 is the insulating material portion and makes up a substantial part of the interior of the connector section 17 of the tool. It is preferably made of moulded polytetrafluoroethylene that is machined to obtain the desired shape and dimensions. This plastic has the desired electric insulating characteristics. However, it was discovered that by making the body 37 from a moulded plastic rod instead of from an extruded one, and by stress relieving it during the manufacturing process, the physical and mechanical properties were greatly improved. No cracks or voids were formed in the material, and the tensile strength was increased very substantially.

A conductor 38 extends axially through the connector section 17. It may be made of an appropriate conducting material but is preferably stainless steel which has been given a highly polished outer surface. It is surrounded by and in intimate contact with the body member 37 over most of the length of the conductor 38 except for terminal elements 41 and 42 (left and right hand ends respectively—as viewed in the drawing). These terminal elements are attached to the ends of the rod 38 in any feasible manner. For example, there is a tapped hole 45 in the left hand end of the rod 38 which receives a correspondingly threaded stud 46 that is integrally attached onto the base of the terminal element 41. This provides for electrical connection to one end of a damping resistor 47 that is schematically indicated. A target 48 is connected to the other end of resistor 47.

The other terminal element 42 (right hand end of connector 38—as viewed in the drawing) is made up of an enlarged end structure. It includes a bell-shaped body that is attached to an enlarged end 49 of the conductor 38. A short threaded extension 51 matches a tapped recess 52 which is located axially within the terminal element 42. The other end of element 42 has a female plug socket which fits over the hub 26 of the adapter plate 30. These are securely attached together for making good electrical and mechanical connection by having an axially located nylon screw 53 which passes through a hole 54 in the terminal 42. There is a tapped hole 57 that is axially located in the tool 11 and centrally of hub 26. This receives the screw 53.

In accordance with good practice the terminal element 42 including the enlarged end 49, is designed to have an acceptably low electric field generated at the surfaces thereof. The minimum electric field is generated according to electric field theory, when the ratio of the radii of coaxial cylinders is equal to the base of natural logarithm or 2.718. However, the maximum diameter of the terminal element 42 is dictated by the width of the mounted capacitors 21 and this still provides a safe voltage gradient that is within the insulating limits for the most adverse conditions of the SF_6 gas in the space 25.

About centrally located along the length of the body member 37, there is an annular chamber 58 that is formed by machining the member 37. There is a conductive material lining or frame 59 that is preferably made of aluminum. This frame 59 acts as a mechanical stiffening element and tends to minimize the expansion of the body member 37. The frame 59 is cylindrical with end flanges and forms an inner lining for the chamber 58. It is constructed with two halves for mounting over the reduced diameter portion of the body 37, and these halves may be held together by tangential bolts (not shown) through lugs 62 that extend radially out from a circumferential rib 60. The rib 60 and a hub 61 provide extra thickness for use in mounting circuit elements (not shown) that are used in connection with the control of the replenisher (not shown) for the neutron generator 31.

It may be noted that an important purpose of having the chamber 58 in the connector section 17 of the tool, is to provide the ability to have the circuit elements for the replenisher controls located as close as possible to the replenisher element without increasing the space between the target 48 and the detector (not shown). As will be appreciated by one skilled in the art of radioactivity logging, a detector will be located as close as feasible to the target of a neutron generator in order to have the level of induced radiations adequate for practical logging operations. However, the replenisher is near the other end of the neutron generator 31 from that shown, and so its control elements would take up shielding space which would mean that the detector would have to be further from the target. Therefore, the chamber 58 enables the closer spacing to be obtained. Such benefit of the chamber 58 with its liner 59 is in addition to the mechanical support for the insulating body member 37. Such support is in fact necessary for containing the expansion of the insulating body member 37 at elevated temperatures.

The ability to have close spacing vis-a-vis the replenisher and its control elements, is of major importance since the requirements of the replenisher controls involve high current at low voltage. This is because the replenisher employs a heating element, and its controls handle relatively high current that would be adversely affected by long circuit connections or connections involving friction contacts, e.g., slip ring connections.

It is pointed out that at the right hand end (as viewed in FIG. 1) of the body member 37, there is a transverse face or surface 63 that acts as an end wall for the high pressure gas space 25 in the high voltage generator section 15. The surface 63 is machined smooth in order to avoid any creepage of corona from the conductor 38 (end 49) to the case 12.

There are, of course, seal structures where necessary to avoid any leakage of the high pressure gas from space 25 in section 15. This is true also with respect to a pair of low voltage electrodes 69 which pass through the right hand end of the body member 37 near the periphery thereof parallel to the axis.

The electrodes 69 are secured in place by having enlarged ends 70 that are partially threaded. These screw into tapped holes in the body member 37, as indicated. The low voltage circuits are carried across the end of the space 25 that surrounds the terminal element 42 of the high voltage conductor 38, and this involves electrical connection from the electrodes 69 which have male plugs 68. There are female plugs in the ends of metal conductors 67, and there are hollow silicone rods 64 that surround these conductors. The rods 64 extend into the counter bores in body 37 to extend the high voltage leakage paths to ground and to hide the male-female connection from the electric field generated on the high voltage electrode.

The longitudinal thrust caused by the high pressure gas space 25 is countered by a locking ring 75 that fits into a groove 76 on the inner periphery of the case 12 at the base of the threads shown. These threads are part of a joint 79 in the case 12. Some counter thrust is first applied as the tool is assembled. Thus, the maximum diameter portion of body 37 is compressed against a thrust ring 73 that is preferably made of aluminum.

There is also provided an O ring seal 74 on the periphery of the maximum diameter section of body member 37. In addi-

tion, it may be noted that in order to assemble the three sections of the tool, the case **12** is constructed with the threaded join **79** as indicated above as well as another similar threaded joint **80**.

It is pointed out that while the body member **37** is machined to provide smooth surface and a close fit with respect to the conductor rod **38** (and end **49**), it is important to also include a layer of an electrically insulating type grease **83** that will cover the surface between the conductor rod **38** and the adjacent surface of the body member **37**. This is important in order to obviate the creation of any air pockets, where a build-up of electric field s would take place. Also, it should be noted that the quality of the grease employed should be such that it does not change state at the elevated temperatures expected or the desired grease seal would be broken. The application of such grease **83** is also placed on the outside peripheral surface **84** of an extension **85** of the body member **37**. This extension is carefully constructed to closely match the inner surfaces of a socket portion **88** of the neutron generator **31**.

On the outer surfaces of the body member **37** there is a coating **89**. This coating mat be any feasible type of conductive material and is preferably a silver paint applied to the surfaces of the member **37** following etching thereof. This coating will act to prevent any build-up of excessive electric fields across air gaps that may exist on the outer surfaces of the body member **37**. Thus, there will be a direct electrical connection to the case **12** created by means of the coating **89** on the outer surfaces of the member **37** and in conjunction with the aluminum lining **59**.

While a particular embodiment of the invention has been described above in considerable detail in accordance with the applicable statutes, this is not to be taken as in any way limiting the invention but merely as being descriptive thereof.

I claim:

1. A high voltage connector for a radioactivity type borehole logging tool neutron generator, said tool having a cylindrical case for enclosing a high voltage generating section, a neutron generator section and a section for said connector, comprising in combination

an axially located conductor having a smooth surface and connecting said high voltage generating section with said neutron generator section

a body of polytetrafluoroethylene insulating material surrounding said conductor in intimate contact therewith over most of the length thereof

said insulating material extending from said high voltage generating section to said neutron generating section and forming a pressure seal for said high voltage generating section

an annular chamber formed in said body of insulating material for containing circuit elements to control the replenisher of said neutron generator.

2. A high voltage connector according to claim **1**, wherein an annular chamber is lined with a metallic frame.

3. A high voltage connector according to claim **2**, further including electrically insulating grease between said axial conductor and said body of insulating material for excluding any air pockets.

4. A high voltage connector according to claim **3**, further including

a smooth surface on said body of insulating material forming an end wall for said high voltage generating section.

5. A high voltage connector according to claim **4**, wherein said smooth surface end wall is substantially perpendicular to the axis of said tool.

6. A high voltage connector according to claim **5**, wherein said axial conductor has a highly polished surface, and said body of insulating material is stress relieved during its manufacture.

7. A high voltage connector for a radioactivity type borehole logging tool neutron generator, said tool having a cylindrical case for enclosing a high voltage generating section, a neutron generator section and a section for said connector, comprising in combination

an axially located solid stainless steel conductor having a polished surface and connecting said high voltage generating section with said neutron generator section,

a body of insulating material constructed of moulded polytetrafluoroethylene surrounding said conductor in close fitting relation thereto over the entire length thereof in said connector section,

a smooth surface on said body of insulating material being substantially perpendicular to the axis of said tool,

said smooth surface forming an end wall for said high voltage generating section,

an annular chamber formed in said body of insulating material near the middle of said connector section for containing circuit elements to control the replenisher of said neutron generator,

an aluminum frame lining said annular chamber and having means for mounting said circuit elements thereon,

an electrically insulating grease located between said axial conductor and said body of insulating material for excluding air pockets, and

an electrically conductive coating on the outer surfaces of said body of insulating material for preventing build-up of excessive electric fields across air gaps adjacent to said outer surfaces.

8. A high voltage connector according to claim **7** wherein said body of insulating material is stress relieved during the manufacture thereof, and said axial conductor surface is highly positioned.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,657,536 Dated April 18, 1972

Inventor(s) OBIE M. LANGFORD

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, Line 70, after "section 15 of the tool." insert the sentence -- Also, there is a hub 26 that is integral with the plate 30. --

Column 4, Line 25, "further" should read -- farther --

Column 6, last word in Claim 8 "positioned" should read -- polished --

Signed and sealed this 5th day of September 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

PO-1050
(5/69)

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